Space Weather Technical Forecast

Issued on Friday, 30 December 2022 at 01:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of Minor Geomagnetic Storms on 30 December. Chance of M-class flares throughout. Chance of Active electron fluence.

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Solar activity has been Moderate over the past 24 hours with two M-class flares emanating from a region just starting to emerge across the eastern limb. In total there are 10 sunspot groups on the visible disc, with the previously distinctive regions in the northwest quadrant continuing to decline and remain inactive. AR3176 is the largest region on the visible disc, but has undergone limited evolution during the 24 hours, although AR3179 is growing relatively quickly from plage.

A CME which lifted from the southwest quadrant either late on 28 or early on 29 December has been analysed and submitted for modelling. Otherwise, no Earth directed CMES were observed in available imagery during the period.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by DSCOVR and ACE at L1, initially decreased from 425km/s to 420km/s due to the waning influence of the high speed stream from coronal hole 57. Winds then continued at 425-450km/s for much of the day, before a marked increase in wind speeds from around 29/2000UTC, reaching speeds of 510km/s. Density was around or below average, but reached above average levels later in the period due to the possible arrival of a CME, as speed and density increased at the same time. However there is a chance that this could also be the CIR ahead of a coronal hole high speed stream. Interplanetary magnetic field strength, IMF, was generally weak, before jumping to moderate levels at around 29/2200 UTC, peaking at 12nT at 30/2302UTC. The north-south component, Bz, varied weakly, but then became sharply southward from 29/2200UTC, reaching a negative peak of -10nT before recovering to weak variations. Phi angle was predominantly positive, towards the Sun, but has been indeterminate since 29/2200UTC. Resulting geomagnetic activity was mainly Quiet to Unsettled, but with an Active interval between 29/2100-2400UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at background levels. High energy electron flux (greater than 2MeV) as recorded at GOES16, started at moderate levels, but reached high levels, with a maximum of 2730 pfu at 29/1550 UTC, before declining back to moderate levels. The 24-hour integrated electron fluence followed a slight rising trend, for much of the period, peak at 8.63e7 integrated pfu before falling back to 8.22e7 integrated pfu by 30/0001 UTC.

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Four-Day Space Weather Forecast Summary
Solar Activity: Solar activity is expected to be Low with a chance of isolated Moderate activity. There is an increasing potential risk of more frequent elevated activity from a region which is rotating onto the eastern limb.

Solar Wind / Geomagnetic Activity: A CME appears to be affecting the Earth, with residual effects possible through the next four days. The high speed stream from coronal hole 59 is then forecast to connect on 30 December, perhaps giving speeds of 500-600km/s, Recent changes in the solar wind could indicate the connection, but current data is inconclusive. Once connected, this is likely to affect Earth for much of the period.

Geomagnetic activity is expected to be largely Unsettled to Active on 30 December with a chance of G1/Minor Storm intervals. This is due to the onset of the high speed stream and CME. Geomagnetic activity and the risk of G1 should reduce through 01 and 02 January as the high speed stream influence slowly eases.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels throughout, with a daily slight chance of reaching S1 levels. High energy electron flux (greater than 2MeV) is likely to remaining muted through 30 and 31 December with a low risk of reaching the high threshold. A recovery is then forecast through the remainder of the period. Electron fluence values are forecast to initially decline, before an increase towards the Active (1e8 integrated pfu) threshold later in the period,

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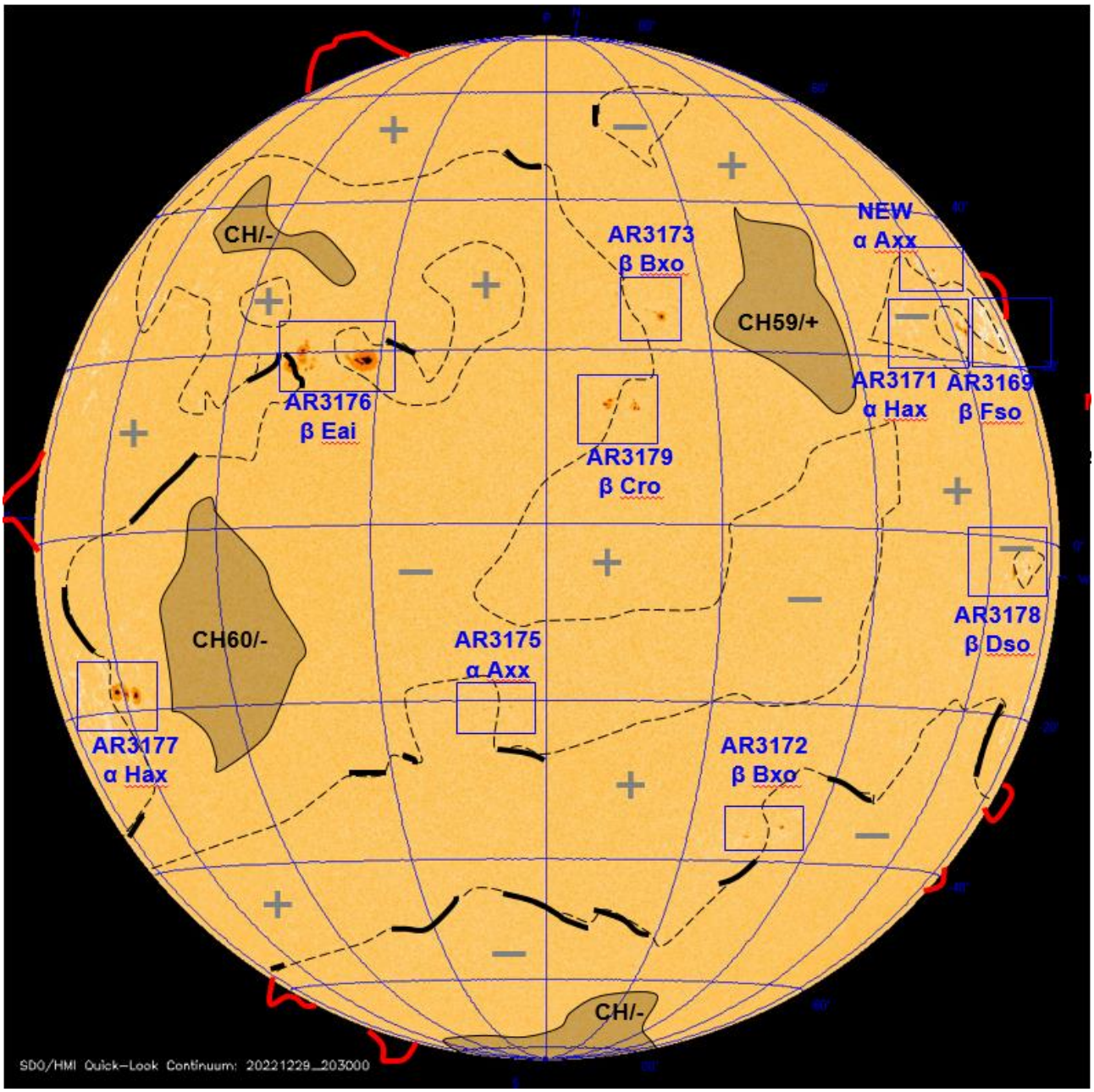
Figure 1. Solar Analysis Valid 29/2000UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME which left the Sun on 25 December may be affecting the Earth currently with coincidental increases in speed and density from around 29/2200UTC, although whether this is a CME or the CIR ahead a high speed stream are inconclusive, with the data continuing to be monitored. No further CMEs are forecast to affect the Earth through the forecast period.
Solar wind speeds are slightly elevated, with speeds reaching around 450km/s. The high speed stream from coronal hole 59 may have recently connected, but if not, it is due to connect with Earth on 30 December with speeds forecast to reach close to 500-600km/s based on analysis of STEREO-A data.

Geomagnetic activity is expected to be Unsettled to Active through 30 December based on the effects of the recent CME and expected coronal hole high speed stream, with a risk of G1/Minor Storm intervals. The influence of both through the forecast period is uncertain, but a general reducing trend in geomagnetic activity is likely through the forecast period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	50	30	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
25/1245	Partial	AR3169	NW quadrant	520 km/s	29 December	Possibly arrived

Figure 2: Recent solar wind data from L1

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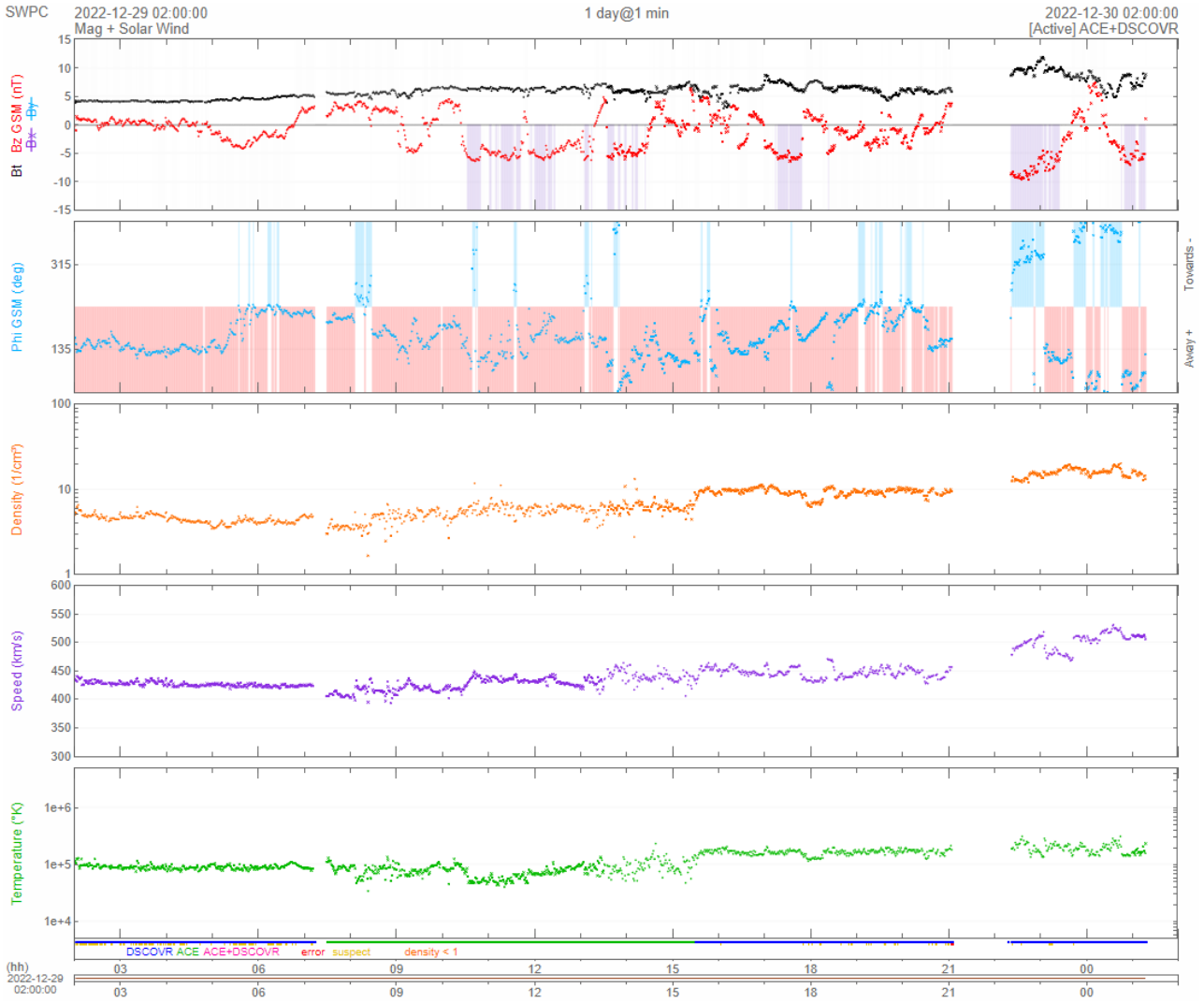

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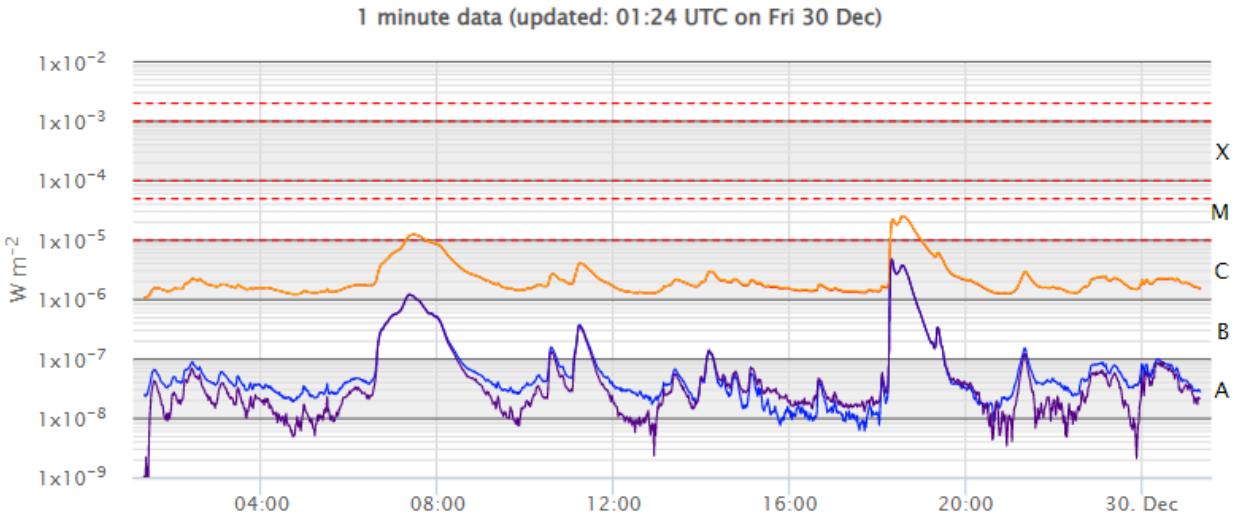
Radio Blackouts - X-Ray Flares:
There are 10 sunspot regions on the visible disc. AR3169 and AR3171, which have contributed much of the risk through the last 14 days, are declining as they rotate towards the northwest limb. The main activity has otherwise been from a region which appears to be on the northeast limb and which has produced two low energy M-class flares through the last 24 hours. On the visible disc the most notable region is AR3176, which appears complex, but has not shown any significant activity. AR3179 has also developing quickly during the last day, but remains relatively simple. The remaining regions are all simple alpha or beta regions.

Solar activity is expected to be mainly Low, with a chance of M-class flaring through the period due to the regions in the eastern hemisphere and the regions just beyond the eastern limb. There is also a low but potentially increasing risk of X-class flares through the period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES 16 X-ray flux for the last 24 hours



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Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (greater than 10 MeV) is currently at Background levels, and is expected to remain generally unchanged through the period.

There remains a slight chance of a proton event reaching the S1 level throughout the period. Although AR3169 is rotating off the disc, the risk of a proton event from this region will remain until it is well over the limb, at which point AR3176 will be in the western hemisphere with an increasing risk from this region.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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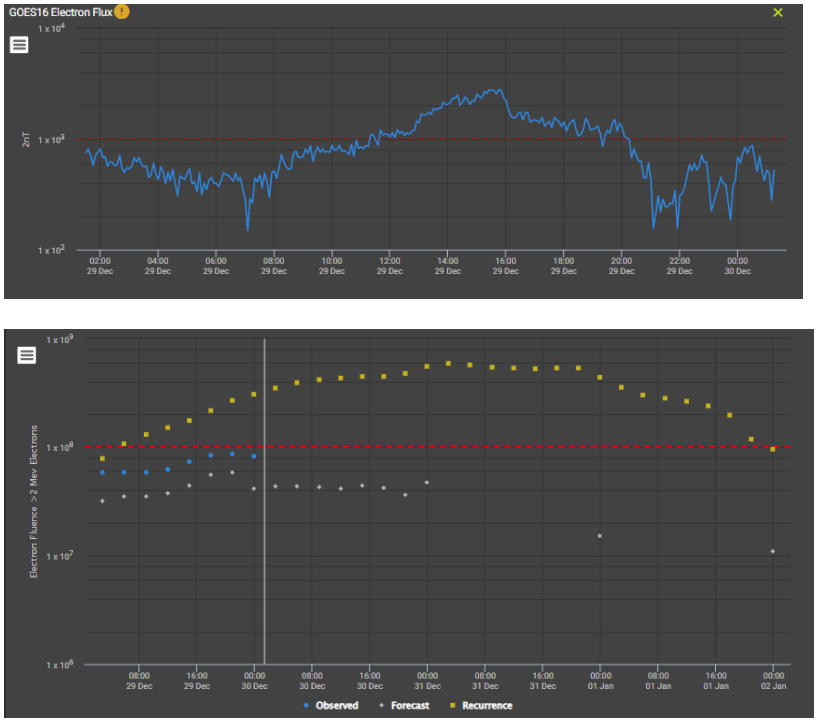
High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has sharply declined due to the recent CME arrival, with this suppression likely to continue through 30 December due to the increased geomagnetic activity and increases in wind speed, both redistributing electrons in the belts and distorting the radiation belts. There is lower than normal confidence in the timing of the arrival of the high speed stream from coronal hole 59, and the subsequent effects of the high speed stream. However the most likely scenario is for the electrons to continue to remain relatively muted through 31 December but with a slowly rising trend and an increasing chance of exceeding the high (1e3 pfu) threshold later in the period.

Electron fluence has been close to the Active (1e8 integrated pfu) threshold, but with recent enhanced geomagnetic and solar wind enhancements, the general trend is expected to be for a decrease through 30 and 31 December. A steady increase through 01 and 02 January is then possible as the above effects subside.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	10	20	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES 16 electron flux and MOSWOC REFM electron fluence forecast model



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